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Mass media and heterogeneous bounds of confidence in continuous opinion dynamics

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HIGHLIGHTS

- We study the DW and HK models with mass media and heterogeneous individuals.
- We analyse two different forms of introducing heterogeneities into the models.
- The persuasion capacity of the mass media is enhanced by diversity in confidence levels.
- If the mass media intensity is too large the persuasion capacity of the external message decreases.
- Similarities and differences between the two models are discussed.

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ABSTRACT

This work focuses on the effects of an external mass media on continuous opinion dynamics with heterogeneous bounds of confidence. We modified the original Deffuant et al. and Hegselmann and Krause models to incorporate both, an external mass media and a heterogeneous distribution of confidence levels. We analysed two cases, one where only two bounds of confidence are taken into account, and other where each individual of the system has her/his own characteristic level of confidence. We found that, in the absence of mass media, diversity of bounds of confidence can improve the capacity of the systems to reach consensus. We show that the persuasion capacity of the external message is optimal for intermediate levels of heterogeneity. Our simulations also show the existence, for certain parameter values, of a counter-intuitive effect in which the persuasion capacity of the mass media decreases if the mass media intensity is too large. We discuss similarities and differences between the two heterogeneous versions of these continuous opinion dynamic models under the influence of mass media.

1. Introduction

The physics of social systems deals with the application of methods from physics to understand the complex mechanisms behind social phenomena. Perhaps one of the most intriguing challenges of this popular topic of research is to explain the development of consensus on some issue out of social interactions, despite that initially all the individuals had different opinions. The usual approach is to set up stylised dynamical models in which properly quantified individual's opinions evolve according to realistic enough communication rules, that define how individuals influence and are influenced by other members of the society [1–3].

Recently, Deffuant et al. (DW) and Hegselmann and Krause (HK) developed a set of models in which opinions are represented by continuous varying quantities [4–6]. To mimic social interactions, both models implement the so-called

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bounded confidence mechanism by which two individuals only influence each other if their opinions differ by less than some amount. Another common ingredient is an agreement mechanism, by which individuals who overcome the bounded confidence condition adjust their opinion towards an average value. In the DW model, a process similar to the collision of two molecules or atoms in the kinetic theory of gases is considered. The opinion of the two individuals changes simultaneously, and there is an extra parameter that controls how fast the opinion converges. This model describes situations where the interaction between individuals occurs face to face. In the HK model, there is no convergence parameter, and the interaction is no longer related with a scattering process, because the individuals simultaneously change their opinions to the average opinion of all other individuals who satisfied the bounded confidence condition (a global communication takes place in large groups). These models of continuous opinion dynamics under bounded confidence may be very useful to analyse cases where one has to respond to a single issue (rating a politician or a product, for example) with a real number which can vary continuously in a certain range. It is already well established that there are different critical confidence levels above which a state of consensus is always reached. Below these consensus thresholds, the population splits into two (polarisation) or more (fragmentation) sets of non-interacting clusters with the same opinion in each of them [6,7]. However, it has been also recognised that such uniform and noninteracting states are not very realistic, this being one of the reasons why several interesting modifications to these models have been recently introduced [1,2,8–10].

Most of the modifications assume situations where all individuals in a given society have the same level of confidence. However, it is clear that due to many complex psychological and physiological factors, a more realistic assumption is to consider systems where individuals are allowed to have different bounds of confidence. Surprisingly, it was found, using an interactive Markov chain formulation, that it is possible to reach spontaneous ordered states (consensus) in the HK model and DW model with two different bounds of confidence, but not for the corresponding homogeneous cases [11]. More recently, a HK type model, where individuals are divided into not just two but several groups, with different bounded confidence levels, was also analysed. In this case, the number of opinion clusters increases with the number of individuals who have a very low confidence level [12]. Several other interesting results about heterogeneous bounds of confidence have also been reported in recent years [13–16].

The dynamics of opinions in real societies is also affected by many exogenous factors, the mass media being one of the most important (T.V., blogs, newspapers, etc.). In this regard and with the aim to make models more realistic, some works study the conditions for an efficient spreading of propaganda in DW type models where homogeneous individuals (equal level of confidence) interact with their neighbours and with the mass media using a bounded confidence mechanism [17–19]. Some of these works have reported the very counter-intuitive observation that the system can spontaneously order in a state different from the one imposed by the mass media, in contradiction with what it is found in classical physics where spin systems monotonously align towards strong external applied fields. It was found that this situation could arise in other non-equilibrium models provided they allow for non-interacting states [20].

However, besides the modified models mentioned above, there are few studies that analyse the combined effect of mass media and heterogeneous bounds of confidence in continuous opinion dynamics [21]. We believe that, given the strong global exchange of information and the strong presence of the media, it is worth to study in more detail the effect of both contributions [22]. In order to shed some light on the emerging phenomena obtained after the combination of the endogenous and exogenous factors described above, we analyse extended versions of the DW model and the HK model in which individuals who have their own bound of confidence are allowed to interact with their neighbours and with an external imposed mass media. We want to analyse the impact of heterogeneous bounds of confidence in the adoption or rejection of an external message or mass media. We also analyse how the combination of these two factors affects the formation of consensus.

In the next section we present the heterogeneous DW model in the presence of mass media. In Section 3, we compare the results of the heterogeneous DW model with the heterogeneous HK model also under mass media. Summary and conclusions are presented in Section 4.

2. The heterogeneous DW model with mass media

Usually, the effects of mass media and heterogeneous bounds of confidence in the DW model are analysed separately. Very few cases consider those ingredients acting together. In this section, we consider a modification in which a heterogeneous distribution of confidence levels and a constant exogenous mass media are added to the original DW rules.

To begin the analysis, let us start with a population composed of N individuals in a fully connected network. The opinion x_n^i on a given issue that individual i has at time-step n is a real variable in the interval $[0, 1]$. We assign to each agent i a constant bound of confidence level, ϵ_i, that runs from 0 to 1. This control parameter reflects the willingness of an individual to change his opinions after interacting with others or with an external mass media. In certain way, ϵ_i, measures the level of tolerance of individual i. We also introduce an external mass media S which in principle can take any value between 0 and 1. Finally, we assign to each individual a constant convergence parameter, $\mu_i \in [0, 0.5]$. Initially, it is assumed that the values x_0^i for each individual are randomly distributed in the interval $[0, 1]$. At time step n, an individual i is selected at random:

1. With probability m, if $|x_n^i - S| < \epsilon_i$, individual i interacts with the external field S such that,

$$x_{n+1}^i = x_n^i + \mu_i(S - x_n^i); \tag{1}$$

if $|x_n^i - S| \geq \epsilon_i$ the opinion of the individual does not change. In any case, the cycle starts again.